More Than Relevance: High Utility Query Recommendation By Mining Users' Search Behaviors

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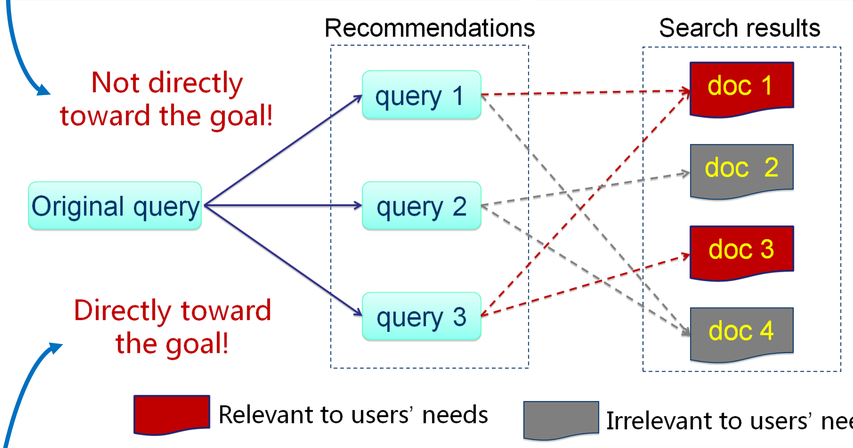
1. MOTIVATION

Relevant query recommendation:
Providing alternative queries similar to a user's initial query

Assumption:
relevant query → relevant results
not necessarily ✗→ satisfy users' needs



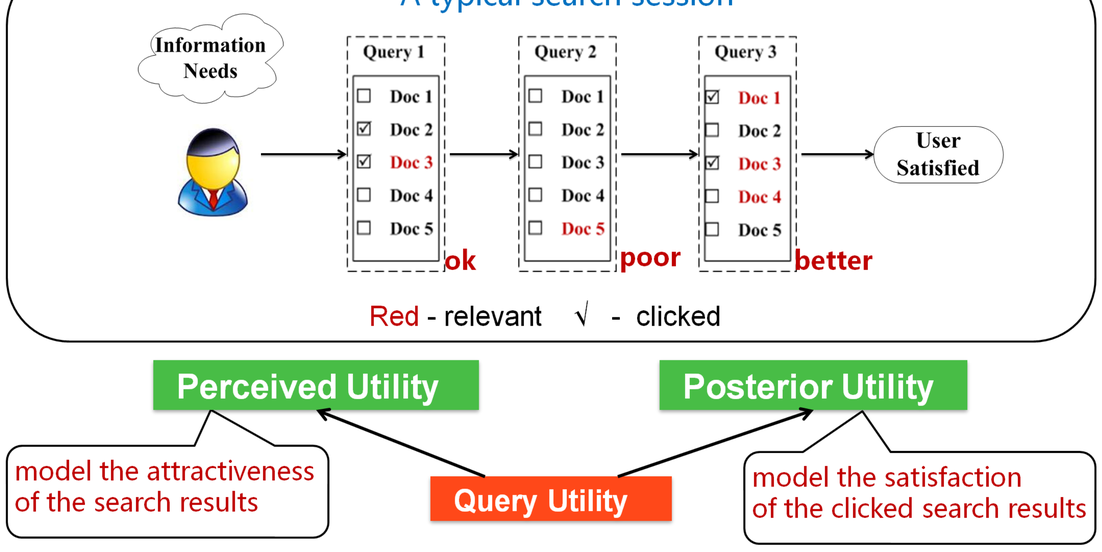
High Utility Recommendation:
Providing Queries that can better satisfy users' information needs

Query Utility Definition:

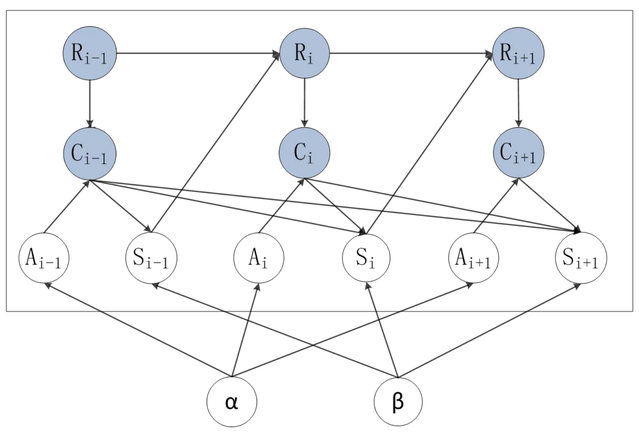
The information gain that a user can obtain from the search results of the query according to her original search intent.

2. KEY IDEA

how to infer query utility ? Key Idea: Through user's search behaviors



3. QUERY UTILITY MODEL



$$P(C_i = 1|R_i = 1, A_i = 1) = 1,$$
$$P(A_i = 1) = \alpha_{\phi(i)},$$
$$P(S_i = 1|C_{1:i}) = \sigma(\sum_{k=1} \beta_{\phi(k)} \cdot I(C_k = 1)),$$
$$\sigma(x) = \frac{1}{1+e^{-x}},$$
$$P(R_i = 1|R_{i-1} = 1, S_{i-1} = 1) = 0.$$

Perceived Utility α : control the probability of the attractiveness

Posterior Utility β : control the probability of users' satisfaction

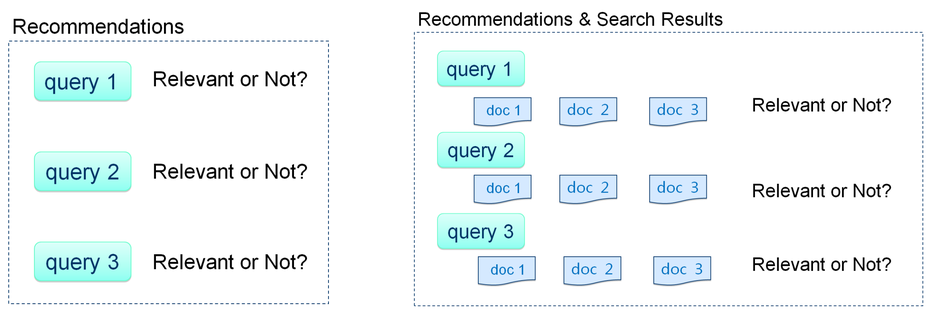
R_i : whether there is a reformulation at position i
C_i : whether the user clicks on some of the search results of the reformulation at position i;
A_i : whether the user is attracted by the search results of the reformulation at position I;
S_i : whether the user's information needs have been satisfied at position i;

Query Utility $\mu_t = \alpha_t * \beta_t$

The expected information gain users obtained from the search results of the query according to their original information needs

4. EVALUATION METRICS

previous Original query — our Original query



– QRR (Query Relevant Ratio)

$$QRR(q) = \frac{RQ(q)}{N(q)}$$

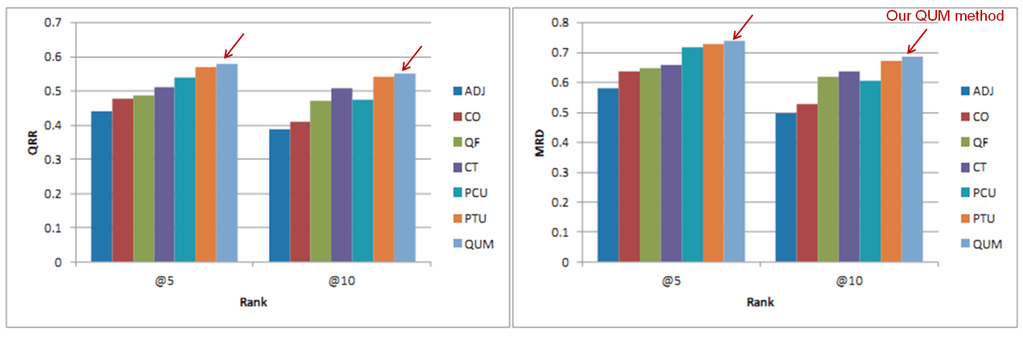
Measuring the probability that a user finds(clicks) relevant results when she uses query q for her search task.

– MRD (Mean Relevant Document)

$$MRD(q) = \frac{RD(q)}{N(q)}$$

Measuring the average number of relevant results a user finds(clicks) when she uses query q for her search task.

5. EXPERIMENTAL RESULTS



(a) QRR (b) MRD

Query Difficulty	Method	QRR @5	QRR @10	MRD @5	MRD @10
Easy	ADJ	0.588(18.64%)	0.526(26.30%)	0.771(20.32%)	0.674(25.22%)
	CO	0.609(14.55%)	0.529(25.63%)	0.830(11.80%)	0.687(22.89%)
	QF	0.618(12.94%)	0.604(9.89%)	0.846(9.67%)	0.806(4.69%)
	CT	0.654(6.62%)	0.635(4.65%)	0.836(11.02%)	0.805(4.79%)
	PCU	0.656(6.37%)	0.611(8.74%)	0.889(4.35%)	0.798(5.79%)
	PTU	0.689(1.22%)	0.663(0.17%)	0.908(2.18%)	0.837(0.86%)
	QUM	**0.698**	**0.664**	**0.928**	**0.844**
Medium	ADJ	0.460(30.00%)	0.429(33.19%)	0.596(24.14%)	0.527(33.76%)
	CO	0.495(20.81%)	0.441(29.65%)	0.640(15.72%)	0.550(28.10%)
	QF	0.511(17.07%)	0.500(14.39%)	0.615(20.43%)	0.630(11.79%)
	CT	0.534(12.07%)	0.549(4.02%)	0.689(7.54%)	0.692(1.81%)
	PCU	0.544(9.91%)	0.485(17.74%)	0.703(5.31%)	0.588(19.76%)
	PTU	0.581(2.87%)	0.557(2.70%)	0.722(2.53%)	0.689(2.18%)
	QUM	**0.598**	**0.572**	**0.740**	**0.704**
Hard	ADJ	0.259(65.27%)	0.216(91.19%)	0.351(54.37%)	0.284(77.27%)
	CO	0.314(36.29%)	0.261(58.17%)	0.412(31.63%)	0.340(48.00%)
	QF	0.324(32.08%)	0.312(32.20%)	0.441(22.94%)	0.414(21.78%)
	CT	0.334(28.08%)	0.343(20.17%)	0.437(24.15%)	0.424(18.85%)
	PCU	0.404(5.90%)	0.324(27.07%)	0.534(1.54%)	0.413(22.02%)
	PTU	0.426(0.28%)	0.402(2.51%)	0.526(3.18%)	0.485(3.92%)
	QUM	**0.427**	**0.412**	**0.542**	**0.504**

The performance improvements are significant (t-test , p-value <= 0.05)

6. CONCLUSIONS

Contribution

- Recommend high utility queries rather than only relevant queries: to directly toward the ultimate goal of query recommendation;
- A novel dynamic Bayesian network (i.e., QUM) to mine query utility from users' reformulation and click behaviors;
- Introduce two evaluation metrics for utility based recommendation
- Evaluate the performance on a real query log and show the effectiveness

Future work

- Extend our utility model to capture the specific clicked URLs for finer modeling
- Extend our utility model to capture the query level utility